A Fission Fragment Rocket Engine Propelled Spacecraft

Robert O. Werka (PI)	Rodney Clark	Thomas K. Percy
Marshall Space Flight Center	Grassmere Dynamics, LLC	SAIC/ESSSA
EV - 72	774 Bob Stiles Rd	ED - 04
MSFC, Huntsville, AL 35812	Gurley, AL 35748-8909	MSFC, Hsv, AL 35812
256.544.1032	256.698.1726	256.544.0397
robert.o.werka@nasa.gov	rod.clark@grassmeredynamics.com	thomas.k.percy@nasa.gov

The March, 2012 issue of Aerospace America stated that "the near-to-medium prospects for applying 'advanced propulsion' to create a new era of space exploration are not very good". In today's world, we operate to the Moon by climbing aboard a Cruise Liner (Saturn 5), sail from the harbor (liftoff) shedding whole decks of the ship along the way (staging) and, having reached the return leg of the journey, sink the ship (burnout) and return home in a lifeboat (Apollo capsule). Clearly this is an illogical way to travel that is forced on Explorers by existing in-space propulsion technology lamented in by Aerospace America. However, the article neglected to consider the one propulsion technology, using today's physical principles that offers continuous, substantial thrust at a theoretical specific impulse above one million seconds. Such an engine unequivocally can create a new era of space exploration that changes the way spacecraft operate.

The NIAC Program of the NASA Office of Chief Technologist awarded a Phase 1 study contract in August, 2011 to investigate how the revolutionary Fission Fragment Rocket Engine (FFRE) technology could be integrated into an advanced spacecraft. This study clearly showed it solved the Aerospace America conundrum. The FFRE combines existent technologies of low density fissioning dust trapped electrostatically and high field strength superconducting magnets. By organizing the nuclear core material to permit sufficient mean free path for escape of the fission fragments at 4% of light speed and by collimating the beam, the FFRE can convert nuclear power directly and efficiently into significant thrust at enormous I_{SP}. The spacecraft hosting this FFRE would be no more complex nor more massive than the International Space Station (ISS) and would employ the successful ISS technology for in-space assembly and check-out. The vehicle elements can be lifted in "chunks" by a Heavy Lift Launcher. This Exploration Spacecraft would only require the resupply of small amounts of nuclear fuel for each journey and would be an in-space asset for decades just as any Cruise Liner is on Earth.

This NIAC study has created the first ever concepts of the FFRE, integrated one design into a host spacecraft concept configured for manned travel, and assessed a round trip journey to Jupiter's moon, Callisto. This unoptimized FFRE provided 10 lbf of thrust at a delivered specific impulse of 527,000 sec for the entire 15 year mission while providing megawatts of electrical power to the spacecraft. The payload of 60 mT, a part of the 300 mT vehicle, was carried to Callisto and back; the propellant tanks holding the 4 mT of fuel were not jettisoned during the mission. The study concluded that the engine and spacecraft are within today's technology, could be built, tested, launched on several SLS (or similar) launchers, integrated, checked out, moved to an in-space base such as at a Lagrange point, and operated for decades.